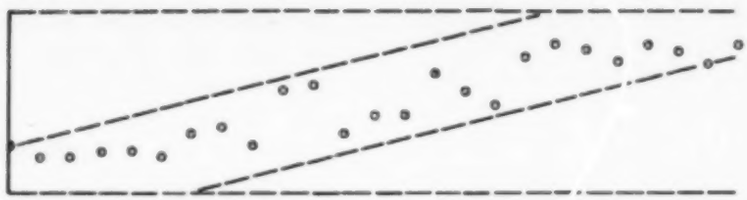
INDUSTRIAL QUALITY CONTROL



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SOCIETY OF QUALITY CONTROL ENGINEERS

IN COOPERATION WITH

THE UNIVERSITY OF BUFFALO

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THE SOCIETY OF QUALITY CONTROL ENGINEERS

OUR SECOND APPEARANCE

For the second time Industrial Quality Control has gone to press. Many verbal and written comments directed at our July publication have been received. It is gratifying that so many individuals, both in and out of the Control Field, have been favorably impressed. May we state here, that we will continue to make every effort to maintain a policy of distributing information concerning our chosen field in an interesting manner. This response is sufficient incentive for the editorial staff to exert even greater effort toward the preparation of a publication which meets your requirements.

A CALL TO ARMS

At this time your Society sincerely urges your active participation in its affairs and solicits your financial support. Your officers believe that our membership desires that both the Society and our publication continue in the course now so well underway.

In the absence of external assistance, we must arrange for our own support. To this end we have organized a large group in Buffalo and the surrounding area, so that the individual burden could be low. Right now is the time to express your appreciation of the conduct of our Society and its publication by sending unpaid dues to our Treasurer, George V. Herrold, 537 Woodland Drive, Kenmore, New York.

TRAINING COURSES

Courses of study in Statistical Quality Control are continuing in Buffalo and in Rochester. May we suggest that these are available to all interested persons, and that your help in procuring students will be appreciated. Further, this is an active way of creating additional potential numbers for our Society.

The University of Buffalo, University of Rochester, and the Rochester Institute of Technology are carrying on this work. Please consult with them for further detailed information.

MEETINGS

Your officers have followed the plan of honoring the graduates of quality control courses at the University of Buffalo with a dinner meeting. We look forward to greeting you and the twenty-five current graduates at the October 9th dinner meeting.

Dr. Douglas Brown of Defense Industries, Ltd. of Canada will be the speaker. The meeting promises to be very stimulating for Dr. Brown, as Manager of Quality for the corporation, is well qualified to speak on quality control as applied in Canadian industry. Notice of the time and place of this meeting will be mailed shortly.

POSTWAR

Industrial management is devoting an increasing amount of money and manpower to planning postwar operations. New problems arise as plans take form. A high ranking new problem grows directly out of the question: "What quality of products will the public demand, and what quality will competition force us to produce?" The answer is that industry must produce at the highest attainable quality level. The maintainance of good quality with uniform characteristics calls for the techniques of the Quality Control Engineer. Management of plants now using the control chart recognize this truism and an increasing number of inquiries from other plants show that expanded use lies immediately ahead.

Your officers are attempting to keep abreast of these developments by fostering two major programs: (1) the training of new quality control operators in courses offered at the University of Buffalo, (2) the publication of Industrial Quality Control.

The magazine is designed to give you articles to show what other companies are doing, bibliographics to guide your reading concerning the use of control techniques in other parts of the country, tables to facilitate your work, and solutions of current problems presented by members of the society.

The demand for trained and experienced Quality Control Engineers exceeds the supply today. In the postwar period the demand will be much greater. Don't miss the opportunity which you have to prepare for a front ranking place in this expanding field.

STATISTICAL QUALITY CONTROL
at
BELL AIRCRAFT CORPORATION

by
James H. Munger
Manager, Statistical Quality Control
Quality Division
Niagara Frontier Division of Bell Aircraft Corporation

It is a generally known and accepted fact that aircraft production operations lend themselves least easily of all classes of manufacture to the basic techniques of controlling quality by statistical methods which have been developed during recent years. The reasons for this are simple; first, the fabrication phase of production is jobbing in nature, involving short production runs of a great variety of detailed parts, second, parts received from sub-contractors are likewise presented in small lots, and finally, in the assembly phase, virtually the only place where straight line production occurs, the operations become intensely complex and involved. Added to this is the fact that the war, which has made possible mass production of aircraft, is in such a continual flux that the impetus of battle experience has made necessary frequent redesigns, sometimes radical in nature. Here, then, is a production situation so unstable in nature as to offer little encouragement to a quality control group.

From another point of view, these same conditions have made necessary the application of statistical techniques in the control of quality. For, in such a situation it should be obvious that the waste production involved in terms of man-hours and material has been enormous. This waste worked its way into the thinking of aircraft people until complacent acceptance of the fact had been reached. High time, therefore, that some agency presented to management the cold hard figures that describe this waste, and pointed out the ways and means of reducing it to a more economical level. That agency was to be statistical quality control.

OPERATING PLAN. The new director of quality at Bell understood these fundamental conditions when he assumed his post in December. Further, he was well informed on the ideas of quality control and believed that they could supply a solution to these waste problems. Therefore, the writer was selected to organize and build the activities of a quality control department. From small beginnings has grown a system of quality control designed to cover the two major plants of the Niagara Frontier Division of the Corporation. Of the 20 personnel in the department, 10 are quality control engineers, 3 are engaged in management duties and the remainder in clerical tasks. The department neither has jurisdiction over nor is responsible to the inspection section of the division, but is directly responsible to the Director of Quality. Hence it enjoys a proper measure of freedom in relaying its information to management in obtaining the inspection cooperation so essential to success.

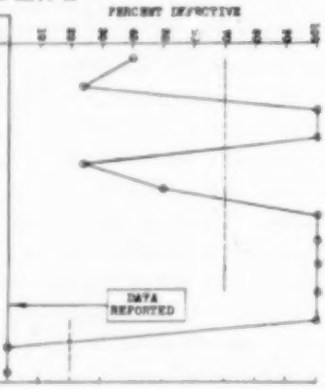
INITIAL PROJECT. The machine shop was selected as the most fruitful place to start product control. All pieces machined are submitted for acceptance inspection to a crib set aside for that purpose. Here a daily report of inspection results is maintained, providing data from which fraction defective charts could easily be constructed. We decided to use these data to develop an index of the quality of production on each of the many parts undergoing processing in the shop. We soon had a month's data compiled in such a way that we could determine quickly the production performance of each piece processed. Many of the parts were running at a satisfactory level, but many others, over 100 in fact, were being produced at a rejection rate well in excess of 20%, some exceeding 60%. A group of these was selected and analyzed. A rejection ticket file developed parallel to the quality index made it possible to determine just why the pieces had been rejected and how they were disposed of. Armed with this information, we were ready to investigate the jobs in process.

Problems arose at this point for, as has already been remarked, aircraft fabrication is short intermittent run type of operation, making it difficult to find the work in process. Moreover, once a part was found, it soon ran out. We did succeed in investigating a few, especially noteworthy being a flanged bushing, which, in volume production, was suffering a 70% rejection rate. Variables control charts revealed wide variations out-

side engineering limits. The causes of these variations were segregated, a method for improving the process was devised and reported together with relevant data. Action was taken immediately. The rejection rate dropped from 70% to about 20%, a much more satisfactory level, and incidentally, netting a saving which has long since covered the cost of operating the quality control department at its present strength. These process changes point to others which production can make to reduce rejections below the present 20% level.

Investigations of this sort require time and our staff was much smaller than it is today. Consequently not more than three or four piece parts could be brought into control at a satisfactory level in a month's time. At least 100 parts were shown by the index to be in need of immediate improvement and many other less serious malefactors were obvious candidates for attention. To expand the quality control department immediately did not appear to be feasible because trained personnel were not available. Hence a somewhat unorthodox plan was adopted. It was decided to place the responsibility for investigation and correction on the shoulders of manufacturing. Accordingly, percent defective charts were prepared on the offending parts, and these together with all relevant quality data including the major causes for rejection and operations charged were sent to management. Supplied with these data, manufacturing is able to set about eliminating the causes of poor production.

QUALITY CONTROL DATA ON
24-741-013-1 COLLAR
PROCESSED IN DEPT. 43



DATE	PROD	REJD	% DEF	SAL	RWK
3/3	344	137	40	0	137
3/4	488	108	94	0	108
3/7	388	388	100	48	304
3/11	216	216	100	216	0
3/15	349	93	94	58	95
3/16	670	335	50	250	85
3/17	224	224	100	224	0
3/20	400	400	100	400	0
3/16	272	272	100	272	0
3/18	573	573	100	573	0
6/20	225	225	100	225	0
7/8	235	0	0	0	0
7/11	680	0	0	0	0

MO	PROD	REJD	% DEF	SAL	RWK	SCRAP
3	2883	1849	62	1196	653	19
5	845	845	100	845	0	0
6	225	225	100	225	0	24
7	918	0	0	0	0	0
Total	4,980	2,919	59	2,266	653	43

REASONS FOR REJECTIONS IN ORDER OF IMPORTANCE	OPER CHG
(1) Flash on knurl does not clean up	1
(2) #10 holes countersunk too deep	2

——— Average percent defective

FIGURE 1

An example of such a report is reproduced in Figure 1. The part was a brass collar, die cast by a vendor, and sent into Bell for machining. The collar is used for making a hand adjustment on a gun, hence the outside diameter is cast with a knurl for hand gripping purposes. After casting, a flash was left on this knurl and the pieces were then machined here: Assuming either that they were not responsible for removal of the flash or that the presence of the flash made no difference, manufacturing at Bell did not remove the flash. Inspection, however, rejected the part for two reasons, first, non-conformance to specifications and second, the presence of the flash defeated the purpose of the knurl, namely, to provide a sure grip. At the outset differing inspection practices made it possible for some lots to pass without removal of the flash. However, inspection soon agreed upon a standard practice of not accepting the piece with the flash on the knurl, but sending them to material review. And so the rejection rate reached a 100% peak.

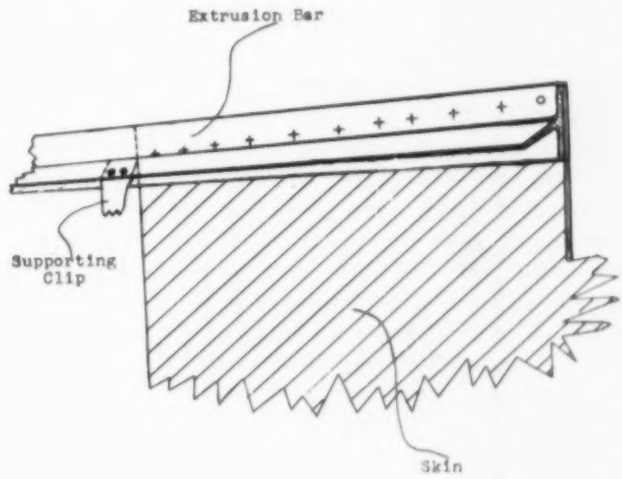
This was the situation when we reported the part. We were soon notified by manufacturing that the flash on the knurl of the collar was a condition created by the vendor and beyond manufacturing's control. Investigation, however, revealed some interesting points: first, that the flash could have been removed easily during the first operation on the turret lathe, second, that to have the vendor remove it would involve a hand operation at heavier expense than it would cost to handle it ourselves, and finally, that the present way of handling the matter, involving sending the lots to salvage and obtaining a salvage repair disposition which called for removal of the flash by hand operations, was the most costly of all methods of accomplishing the job. In view of this we immediately sent a second report requesting that production remove the flash during the first operation. This was done and the graph reveals the maximum benefit obtainable, a drop from 100% defective to 0% defective!

Under this plan the quality control department is responsible for the recognition of poor quality, for the cataloging of causes of poor quality, and for reporting these conditions to management. The department also makes follow up reports at intervals of six weeks, showing what manufacturing has accomplished toward improving operations previously reported as unsatisfactory. Manufacturing accepts responsibility for the engineering type of research necessary to ferret out machine and operating faults and for putting into operation changes in procedure designed to improve quality. The unique arrangement by which reports of the quality control department go up to management and are then transmitted to manufacturing is a product of the existing organization plan of the Corporation. Admittedly something is lost from the standpoint of efficiency; on the other hand, the plan has been effective and will continue to be used until manufacturing is completely convinced of the advantages of statistical analysis and control.

Somewhere in the future measurement charts will be installed on individual machines to achieve uniform product free from defective pieces. In the meantime under the stress of wartime conditions the existing program is bringing three constructive results; (1) marked quality improvement in most of more than 100 piece parts reported to management as having notoriously poor quality records; (2) general reduction of rejection levels throughout the shop; (3) recognition by inspection and production supervision that quality control technique is a constructive device for the solution of production problems.

ASSEMBLY OPERATIONS - WING. Our first move into assembly was made at the Elmwood Plant where King Cobra wings are assembled on a moving production line. On these operations two kinds of quality data were available: number of crabs and number of salvages. The crabs per wing were rather few, and relative to salvages, unimportant. On the other hand, salvages were running high, about 20 per wing, and replacement and correction were costly. We decided to make salvages the subject of our first efforts.

A rejection ticket is written when a salvage repair is necessary. These tickets, therefore, provided working data. They were filed by detailed part numbers for a month's time. It was soon evident that a few of these details were suffering a heavy salvage rate. The relevant rejection data for these parts was transcribed from the rejection ticket to a rejection analysis sheet. From this sheet the engineer was soon able to discover the major reason for the rejection. Thus informed, he was ready to investigate the situation on the line, determine why the salvages were continually occurring, find a way of eliminating the difficulty and prepare a report including the data, an explanation of the cause of the difficulty, and a suggestion for rectifying it. The quality office maintains for each salvage reported a graph showing before and after data. In this way we are able to determine whether or not anything is accomplished to improve the condition. If the graph shows a tendency for the part to disappear from the rejection category, the case is closed. If, after a reasonable lapse of time, no improvement is evident, a follow up report is made. Thus each difficulty is kept under careful and continuous scrutiny.



o = Location of Lofted Hole

\+ = Holes located in Extrusion Bar by drilling thru Lofted Holes in Skin

FIGURE II

An excellent case in point to illustrate this procedure is the problem around which

our first report revolved. As the data came in and began taking shape, we were soon aware that one of the skins and an extrusion bar to which it was riveted were suffering a rather heavy salvage rate. In fact 30% of all the panels produced during the observation period underwent a salvage repair on the assembly of these two details. The total salvages recorded against these two details represented 2% of all the salvages charged to wing line operations during the same period. To put that another way, if this case and 49 others of equal importance could be cleared up, there would be no more salvages.

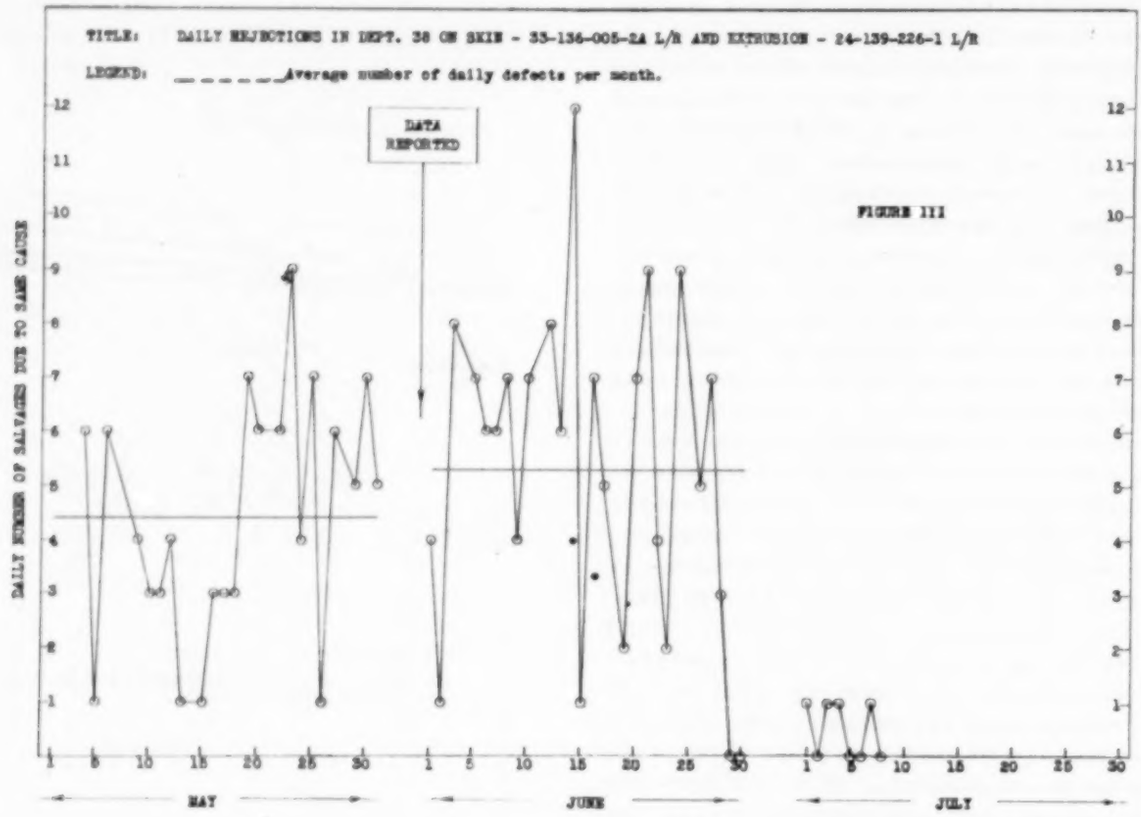

TITLE: DAILY REJECTIONS IN DEPT. 38 ON SKIN - 35-136-005-2A L/R AND EXTRUSION - 24-139-226-1 L/R
LEGEND: _ _ _ _ _ Average number of daily defects per month.
DATA REPORTED
DAILY NUMBER OF SALVAGES DUE TO SAME CAUSE
MAY
JUNE
JULY

FIGURE III

Analysis of the cause of this condition was rather simple. (See Figure II). The extrusion, a "I" shaped one, floats about 9" beyond its last point of support. Along the cross bar of the "I" the skin is riveted to this floating end. There are ten lofted holes in the skin, one in the extrusion. The lofted hole in the extrusion is at the end of the bar and is intended to line up with a corresponding hole in the skin. After this is accomplished, nine more holes are located and drilled into the extrusion bar from the nine lofted holes in the skin. As the driller approached the point at which the extrusion bar was supported, the drilled holes in the extrusion bar came progressively closer to the radius on the other side of the extrusion, that is, they approached the center of the extrusion. This made it impossible to rivet, frequently caused irreparable damage to the extrusion necessitating its replacement or else made it necessary to plug up the holes and drill new ones, not a very desirable practice.

It was evident that the lofted holes in the skin were mislocated. We therefore reported the condition, included the data sketched above, and recommended that the template used to fabricate and loft the skin be checked for the location of these holes. The check made by engineering not only revealed that the holes in question were mislocated in the template, but that the template itself was a "bootleg" template and not the one authorized for use by the lofting department. Shop was immediately prohibited from using the defective template and the correct template was made available. Figure III portrays the results. The chart simply tells how many salvages occurred from day to day for the condition under investigation. Although an in-

crease in the daily average after reporting might lead one to think that the process deteriorated further during June, this actually was not the case. Two factors explain the high level of salvages during June, first, an increase in the number of panels produced, and secondly, the assembly of stock on hand fabricated from the wrong template. The salvages decreased sharply at the end of June with the introduction into assembly of skins fabricated from the correct template. Here, then, is the successful conclusion to that problem.

Reports of this nature are being made continually as analysis of the data brings to light faulty assembly operations. Since this work has been in progress, the average number of salvages per panel has fallen off from 18 to 9. Although much of this improved performance can be credited to production experience, our work has served to throw an additional weight into the balance.

FINAL ASSEMBLY. The results achieved in wing assembly and machine shop persuaded management of the soundness of and need for these techniques of controlling quality. We were therefore requested to establish at the Falls Plant a system to deal with the quality problems entailed in the assembly of the plane.

Our initial survey of Falls assembly operations revealed several kinds of data worthy of attention. These were salvages and crabs, and of the crabs some were repetitional, some infrequent of occurrence but very vital, some neither consequential nor repetitional, Unlike wing assembly operations, the frequency of crabs per ship was running into very high figures. We decided, therefore, to direct our first efforts toward the problem of reducing crabs.

The crab items of considerable individual importance, however infrequent their occurrence, were the subject of our first analysis. Two sources of data were tapped; the crab sheets and information direct from the assembly processes. Each day the engineer goes over all of the crab sheets which are written in the assembly department to which he is assigned. From his knowledge of the process he is able to take from these sheets those items which are of importance, both from a production and safety viewpoint. At regular intervals he also checks the line for important items that are occurring, assisted in these observations by inspection supervision who call such matters to his attention. Some of these items are "hot" and are cleared immediately.

These crabs are handled simply and effectively. The crab is entered on a control sheet, a sheet for each ship number, as many entries per sheet as have been gathered pertaining to that ship. The ship records are then obtained. The operation that should have handled the crab, the inspector who approved the operation, responsible inspection and production supervisors, and the department are determined. This information is immediately reported both to production and inspection supervision, who in their turn inform the responsible individuals. Records are kept for each inspector who is found responsible for approving such defective assemblies. The record of inspection errors provides inspection supervisors with an index to the efficiency of their personnel.

Here are some of the crabs handled in this manner. In several instances bucking bars or other foreign material were found inside an empennage or wing assembly. Were these not detected, the loose parts could easily rip open a skin in the course of flight. As it was, enough damage was done removing them since in a few cases it was necessary to cut open the skin. In another case someone used grease on a rubber fuel line to facilitate its assembly. This condition was not detected by the inspector who first checked the assembly. Of course, the fuel line had to be removed. Some day a pilot flying that plane would have been unable to get gasoline from a full wing tank had this condition not been discovered. Another crab arose when screws which were to hold the landing flap to the wing were found to be loose. Another case was that of a screw so installed that it began to penetrate an oxygen line. Again grease was found on a fiber nut plate, a vital part of the attaching arrangement of a large cowl located just behind the propeller spinner. Here again grease would cause deterioration of the fiber with a good probability that the cowl would some time rip off in flight. These and many more cases are being investigated regularly by our engineers. The fixing of responsibility in proper quarters and notifying individuals of their errors is having a very salutary influence on the whole inspection department. As a result, inspectors are redoubling their efforts and renewing their vigilance.

As the work on these serious items began progressing smoothly, an analysis of the crab sheets for repetitive items was undertaken. In preparing this analysis, we decided not to set up broad categories into which the crabs could be sorted. Such a practice would result in the loss of too much detailed information which we felt was necessary for remedial purposes. Instead individual crabs are checked for frequency of occurrence. The analysis is set up in weekly banks of 25 ships. The engineer goes over the data from 5 ships each day for five days. The data are so drawn as to make an equal coverage between the two shifts spread out among as many of the inspectors as possible. Thus is obtained a representative picture of the week's production. Here, obviously, is a practical sampling improvisation that has enable us to make economical use of our personnel.

The nature of the repeating crabsthat has come to light from these weekly reports is, in some cases, surprising. For example, one crab occurred regularly without fail--"Check electrical equipment with power". This was a regular inspection function but because the power is usually not available when he is ready to perform the inspection, the inspector writes the crab to remind both himself and production that the electrical instruments are not yet checked. Similar to this is the crab "Knock out door". A lever is attached to the door and the door itself so arranged that when the lever is lifted and pressure applied to the door, the door will fall away from the ship. This is for emergency purposes in flight when it becomes necessary for a pilot to abandon ship. The inspector tests the door for this operating characteristic. However, a production man must be on hand to catch the door when it falls. Since such a happy situation seldom occurs, the crab is written to remind inspection and production to perform this operation. The reader may reflect that here are regular inspection operations that should regularly be performed and accounted for. Possibly the solution here is simply to incorporate them into the inspection operation sheets.

In reporting these items, the average times occurred per ship is calculated. If an item occurred 10 times against 25 ships, this would mean that each ship carried .4 of an item on the average. The previous 2 weeks average is always presented so that a comparison is available between present and past performance. One item "Clear pressure lines from inboard side of cabin heater assembly" occurred at a frequency of .32 per ship one week, followed immediately by a .56 average the next week. This was reported and fell off sharply to an .08 average for the two succeeding weeks. Another "Clear fuel and oil lines above sloping deck at former" appeared to be vanishing at successive weekly averages of .20, .16 and .08. Then it suddenly came in .40, at which time it was reported. Another case, which rose sharply from .04 to .76, was "Rubber fuel hose in square access compartment aft of strut rides bulkhead". It was immediately reported but repeated at .08 the following week. Another very interesting case was the crab "Main wheel fairing loose". This rose from .04 to .12 to .36. A check on it revealed that some inspectors were crabbing this item, some not. Inspection supervision had secured engineering approval to the effect that the main wheel fairing should be loose, but had failed to inform all the inspectors of this. The result was a confusion of practice revealed by our figures which sent supervisors scurrying after inspectors to get correctness and consistency in practice.

This work at the Falls has been in progress now for more than a month. Good results, even in this short period of time, can already be shown. Salvage problems come next. Plans are now being drawn up for this work patterned after the method followed at the Elmwood Plant. Data for August are in the process of compilation. Based on our other experiences, we can definitely forecast that certain assembly operations will be disclosed in poor shape, awaiting the attention of a quality control engineer.

RECEIVING INSPECTION. Receiving Inspection at Bell as it stands today is not the happy hunting ground for the engineer who has ambitions to set up sampling procedures. Small lots of about 25 to 100 pieces are the rule. Standard parts, however, bolts, nuts, screws, elbows, etc. are received in large quantities. Here we have set up a sampling procedure based on the Dodge-Romig Tables which provides definite protection guarantees and inspection economy. These tables are sufficiently broad of scope to cover virtually all of the sampling problems encountered. A few of these problems may require special treatment. In addition to the sampling we are maintaining a record

of the incoming quality level of subcontractors' parts based on inspection results. These data are summarized every 3 months. The summaries have revealed that certain vendors are consistently submitting defective material. This information is used chiefly by the Purchasing Department who drop offending vendors and turn the work toward those who have demonstrated their ability to produce satisfactorily. In this way there is brought about an improvement in the quality of submitted material.

SUMMARY. Here in broad outline is the system of quality control developed at Bell during the last half year. Although quality improvement and substantial savings from these activities are generally recognized in the plant, there remains plenty of opportunity for development of technique and expansion of coverage. The methods employed to date are essentially simple, but quite adequate for dealing with the problems encountered during the initial phases of the program. Subsequently more complicated problems requiring refinements of technique will come within the scope of the department.

These applications have yielded what appears to be an effective method of dealing with fabrication processes which are short run in nature. Out of the venture into the field of complicated assembly operations has been developed a mode of attacking faults in final assembly operations which, during the short period of its trial, gives promise of producing results. In sum, the work thus far seems to demonstrate not only the feasibility but also the necessity of applying statistical techniques for controlling quality in production operations. In a broader sense, this work combines with that of many other companies to make an irrefutable case for statistical quality control in aircraft.

CURRENT QUALITY CONTROL ARTICLES

THE GLASS INDUSTRY

In the August and September issues of The Glass Industry, Journal of Glass Manufacturing, there appears Parts I and II, respectively, of an article by J.M. Juran titled "The A.B.C. of Quality Control". This article features applications of control technique in the production of electrical equipment, an analysis of types of engineering action to be followed when various relations appear between control of product and specification tolerances. The attention of readers is directed particularly to the section dealing with "The Plant Executive and the Control Chart."

AERO DIGEST

The September 1 issue of Aero Digest contains an article by James R. Crawford, entitled "Mathematics of Quality Control." The material is very carefully presented so that no one need be frightened by the title. The emphasis is on the rise of the properties of the frequency distribution as a basis for interpreting a control chart.

S.S.I.Q.C.

The Syracuse Society for Industrial Quality Control was formed by graduates of the eight day intensive course given at Syracuse University last January and jointly sponsored by the University and the office of Production Research and Development of the War Production Board. The Society has conducted jointly with the University four continuation meetings since January.

Dr. Martin A. Brumbaugh of the University of Buffalo led the discussion at the February 18 meeting of problems relating to set up of control programs. On March 31, Mr. Richard Coolbaugh of the Easy Washing Machine Company presented a paper entitled "Application of Control Charts to Screw Manufacture." Again on May 19 the Society met and hear Mr. Karl Nilsson of Solvay Products Corporation present the story of the use of control charts in the analysis of a chemical engineering problem. Dr. Edwin G. Olds and Mr. Paul Peach of the Office of Production Research and Development were present at this meeting and contributed to the discussion.

At the September 8 meeting, Mr. Joseph Schrader of Crucible Steel Company spoke on "How Steel is Made and Opportunities for Control". Mr. Richard Coolbaugh aided by colleagues from Easy Washing Machine Company presented features of his control program.

NEW DEVELOPMENTS

In this section of each issue is presented one or more new developments in the field of Quality Control.

CONTROL CHARTS FOR NONSYMMETRICAL DISTRIBUTIONS *

The control chart technique is based on the principles of the frequency distribution. Specifically, analysis by means of the charts implies that the measurements involved are distributed about an average symmetrically and in form resemble the bell-shaped or normal distribution. An exception to this general statement is the case of the fraction defective chart when "p" becomes small and the distribution approaches the Poisson exponential form. To avoid constant reference to this exception the subsequent discussion will be confined to the methods of analyzing records of measurements of piece parts and other materials.

With very few exceptions measurements will be distributed symmetrically about their own average. Nevertheless exceptions occur and for that reason makers of control charts should be alert to recognize the symptoms of an unsymmetrical distribution. The obvious method of investigation is to prepare a frequency distribution of several hundred measurements and study the characteristics of that distribution.

This procedure can be followed only after a considerable number of samples have been drawn and the measurements charted. A method of detecting lack of symmetry from the appearance of the control charts would be much more valuable to the control statistician. Within limits, this is possible. Figure I gives the distribution of a universe of chips from which successive samples of 5 were drawn. The curve is nonsymmetrical but becomes symmetrical if a ratio base scale is used as shown in Figure II.

Figure III shows the $\bar{x}$ and R charts for 100 samples drawn from the logarithmic distribution. The number of averages lying in each sigma band is shown at the right along with the normal distribution. There are 55 averages below $\bar{\bar{x}}$ and 45 above. There is less than the expected number of points between $+\sigma$ and $+2\sigma$, also more than the expected number between $+2\sigma$ and $+3\sigma$ and between $-\sigma$ and -2σ. There is one point out of control. However, none of these features is conclusive even though collectively they suggest that the distribution is unsymmetrical. The conclusive feature of the $\bar{x}$ chart is the absence of points between -2σ and -3σ.

The definitive indicator is to be found in the R chart with 7 points out of control. These samples were drawn from a controlled universe. Therefore no point, or at most one point, could legitimately be expected to be outside the control limit.

The problem of the operator is to distinguish this case, in which points are out of control because we are dealing with an unsymmetrical distribution, from a symmetrical distribution which produces points out of control because of assignable causes. The sequence should be to investigate the process for assignable causes in the usual manner. If the investigation does not yield results the next step should be a study of the control charts for evidences of an unsymmetrical distribution.

If a distribution turns out to be unsymmetrical, there are two types of procedure that can be followed: (1) to rely directly on frequency distribution analysis using a base scale adjusted so as to produce a symmetrical frequency curve, (2) to prepare a control chart with an adjusted vertical scale. Either of these methods requires further explanation which must be postponed to a future issue of of the magazine.

There are many forms of unsymmetrical distributions. Even a logarithmic form may be the reverse of the illustration used here. Whatever the particular form, its presence should be recognizable by the $\bar{x}$ chart or the R chart or both. The logarithmic distribution is the most common of the unsymmetrical distributions and perhaps will be encountered more frequently than the others. Hence, this subject will be followed in the next issue of Industrial Quality Control by the detailed presentation of an example of a logarithmic distribution and the method to be used in setting up a control chart which can be used during production. It is hoped that this added tool will be a valuable aid to those people engaged in statistical quality control work.

* The basic idea of this article was supplied by Mr. Karl Nilsson, Quality Engineer, Solvay Process Co., Solvay, New York.

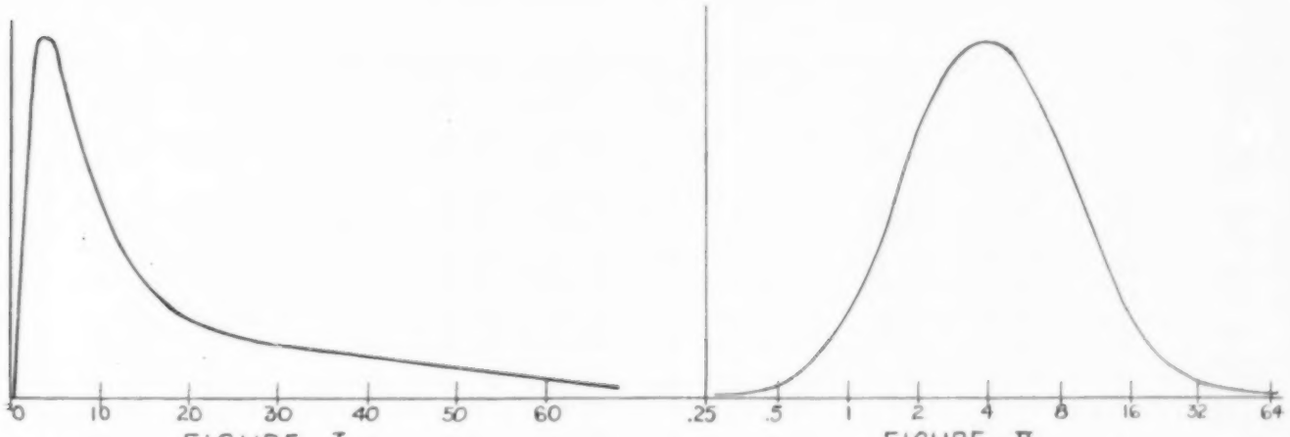


FIGURE I

FIGURE II

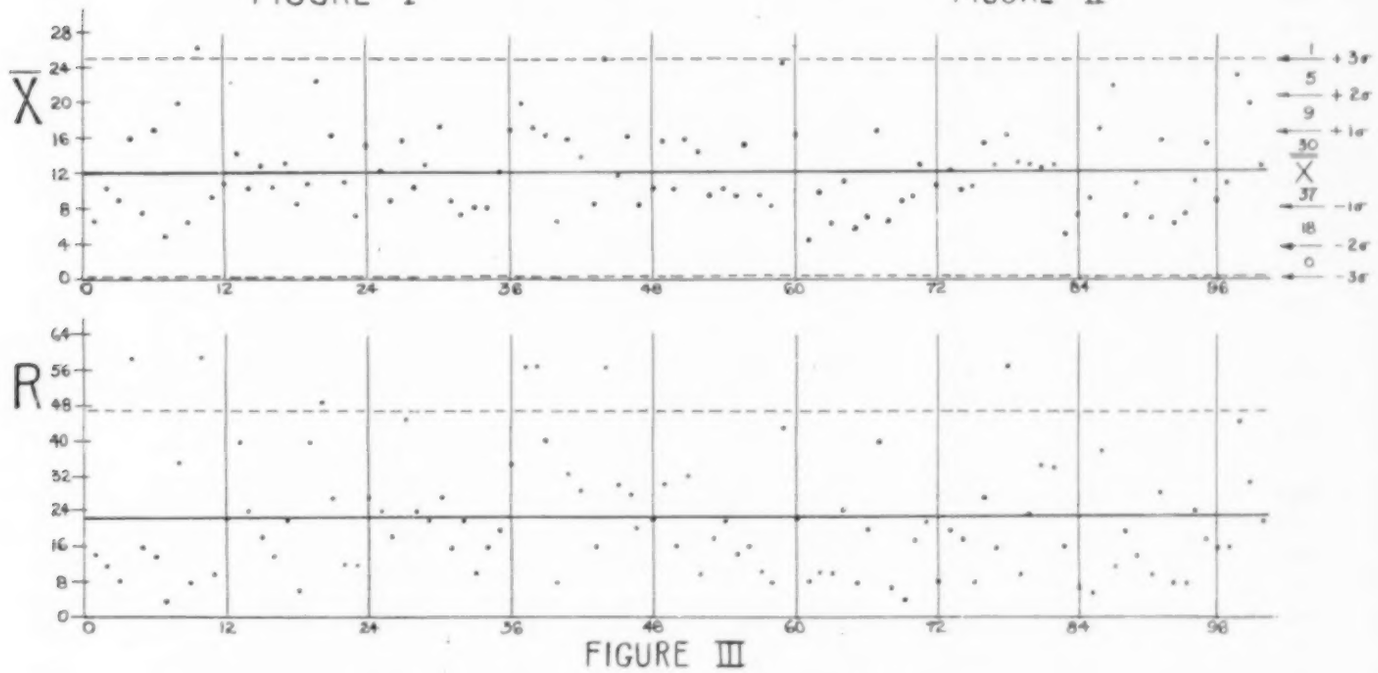


FIGURE III

TABLE OF LIMITS FOR CHARTS FOR DEFECTS

by Vernon Grom
Quality Control Head
Curtiss-Wright Corporation

A table of σ upper and lower limits to be used in preparing charts for number of defects per unit appears on pages 12 and 13. The values of the limits are solutions of the expression $\bar{c} \pm 3\sqrt{\bar{c}}$ for various values of $\bar{c}$ from 1 to 499. To save space the table has been arranged so that the limits for successive integral values of $\bar{c}$ can be read across the rows of the table. Values of $\bar{c}$ at intervals of ten appear at the left of each page of the table and the unit digit in each case can be read from the top of the table. Thus the limits for $\bar{c} = 156$ are 193 and 119, read from the column headed 6 and the row labeled 150 at the left.

3 σ CONTROL LIMITS FOR CHARTS FOR DEFECTS ($\bar{c}$ or $\bar{p}n$)

$\bar{c}$		0	1	2	3	4	5	6	7	8	9
0	U		4.7	6.9	8.9	10.8	12.5	14.2	15.7	17.3	18.8
	L		0	0	0	.1	.2	.5	.9	1.4	2.0
10	U	20.2	21.7	23.1	24.5	26.0	27.4	28.7	30.0	31.3	32.6
	L	2.8	3.5	4.2	4.8	5.5	6.2	6.8	7.5	8.2	8.8
20	U	33.9	35.2	36.5	37.8	39.0	40.3	41.5	42.8	44.0	45.2
	L	9.5	10.2	10.8	11.5	12.2	12.8	13.5	14.1	14.8	15.5
30	U	46.5	47.7	49.0	50.2	51.4	52.7	54.0	55.2	56.5	57.7
	L	16.1	16.8	17.5	18.2	18.8	19.5	20.2	20.9	21.6	22.3
40	U	59.0	60.2	61.4	62.7	63.9	65.1	66.3	67.6	68.8	70.0
	L	23.0	23.7	24.4	25.1	25.8	26.5	27.2	27.9	28.6	29.3
50	U	71.2	72.4	73.6	74.8	76.0	77.2	78.4	79.6	80.8	82.0
	L	30.0	30.7	31.4	32.1	32.8	33.4	34.1	34.7	35.4	36.1
60	U	83.2	84.4	85.6	86.8	88.0	89.1	90.4	91.6	92.7	93.9
	L	36.8	37.6	38.4	39.2	40.0	40.8	41.6	42.4	43.3	44.1
70	U	95.1	96.3	97.5	98.6	99.8	101	102	103	104	106
	L	44.9	45.7	46.5	47.4	48.2	49	50	51	52	52
80	U	107	108	109	110	111	113	114	115	116	117
	L	53	54	55	56	57	57	58	59	60	61
90	U	118	120	121	122	123	124	125	127	128	129
	L	62	62	63	64	65	66	67	67	68	69
100	U	130	131	132	133	135	136	137	138	139	140
	L	70	71	72	73	73	74	75	76	77	78
110	U	141	143	144	145	146	147	148	149	151	152
	L	79	79	80	81	82	83	84	85	85	86
120	U	153	154	155	156	157	159	160	161	162	163
	L	87	88	89	90	91	91	92	93	94	95
130	U	164	165	166	168	169	170	171	172	173	174
	L	96	97	98	98	99	100	101	102	103	104
140	U	175	177	178	179	180	181	182	183	184	186
	L	105	105	106	107	108	109	110	111	112	112
150	U	187	188	189	190	191	192	193	195	196	197
	L	113	114	115	116	117	118	119	119	120	121
160	U	198	199	200	201	202	204	205	206	207	208
	L	122	123	124	125	126	126	127	128	129	130
170	U	209	210	211	212	214	215	216	217	218	219
	L	131	132	133	134	134	135	136	137	138	139
180	U	220	221	222	224	225	226	227	228	229	230
	L	140	141	142	142	143	144	145	146	147	148
190	U	231	232	234	235	236	237	238	239	240	241
	L	149	150	150	151	152	153	154	155	156	157
200	U	242	244	245	246	247	248	249	250	251	252
	L	158	158	159	160	161	162	163	164	165	166
210	U	253	255	256	257	258	259	260	261	262	263
	L	167	167	168	169	170	171	172	173	174	175
220	U	264	266	267	268	269	270	271	272	273	274
	L	176	176	177	178	179	180	181	182	183	184
230	U	275	277	278	279	280	281	282	283	284	285
	L	185	185	186	187	188	189	190	191	192	193
240	U	286	288	289	290	291	292	293	294	295	296
	L	194	194	195	196	197	198	199	200	201	202

3 σ CONTROL LIMITS FOR CHARTS FOR DEFECTS ($\bar{c}$ or $\bar{p}n$)

$\bar{c}$		0	1	2	3	4	5	6	7	8	9
250	U	297	299	300	301	302	303	304	305	306	307
	L	203	203	204	205	206	207	208	209	210	211
260	U	308	309	311	312	313	314	315	316	317	318
	L	212	213	213	214	215	216	217	218	219	220
270	U	319	320	321	323	324	325	326	327	328	329
	L	221	222	223	223	224	225	226	227	228	229
280	U	330	331	332	333	335	336	337	338	339	340
	L	230	231	232	233	233	234	235	236	237	238
290	U	341	342	343	344	345	347	348	349	350	351
	L	239	240	241	242	243	243	244	245	246	247
300	U	352	353	354	355	356	357	358	360	361	362
	L	248	249	250	251	252	253	254	254	255	256
310	U	363	364	365	366	367	368	369	370	371	373
	L	257	258	259	260	261	262	263	264	265	265
320	U	374	375	376	377	378	379	380	381	382	383
	L	266	267	268	269	270	271	272	273	274	275
330	U	384	386	387	388	389	390	391	392	393	394
	L	276	276	277	278	279	280	281	282	283	284
340	U	395	395	397	399	400	401	402	403	404	405
	L	285	286	287	287	288	289	290	291	292	293
350	U	406	407	408	409	410	412	413	414	415	416
	L	294	295	296	297	298	298	299	300	301	302
360	U	417	418	419	420	421	422	423	424	426	427
	L	303	304	305	306	307	308	309	310	310	311
370	U	428	429	430	431	432	433	434	435	436	437
	L	312	313	314	315	316	317	318	319	320	321
380	U	438	440	441	442	443	444	445	446	447	448
	L	322	322	323	324	325	326	327	328	329	330
390	U	449	450	451	452	454	455	456	457	458	459
	L	331	332	333	334	334	335	336	337	338	339
400	U	460	461	462	463	464	465	466	468	469	470
	L	340	341	342	343	344	345	346	346	347	348
410	U	471	472	473	474	475	476	477	478	479	480
	L	349	350	351	352	353	354	355	356	357	358
420	U	481	483	484	485	486	487	488	489	490	491
	L	359	359	360	361	362	363	364	365	366	367
430	U	492	493	494	495	496	498	499	500	501	502
	L	368	369	370	371	372	372	373	374	375	376
440	U	503	504	505	506	507	508	509	510	511	513
	L	377	378	379	380	381	382	383	384	385	385
450	U	514	515	516	517	518	519	520	521	522	523
	L	386	387	388	389	390	391	392	393	394	395
460	U	524	525	526	528	529	530	531	532	533	534
	L	396	397	398	398	399	400	401	402	403	404
470	U	535	536	537	538	539	540	541	543	544	545
	L	405	406	407	408	409	410	411	411	412	413
480	U	546	547	548	549	550	551	552	553	554	555
	L	414	415	416	417	418	419	420	421	422	423
490	U	556	557	559	560	561	562	563	564	565	566
	L	424	425	425	426	427	428	429	430	431	432

CURRENT PUBLICATIONS AND BIBLIOGRAPHY

A page of each issue of the Journal is devoted to brief reviews of articles on Statistical Quality Control appearing in current publications. Earlier issues of the Journal contain bibliographies of materials published in former years. The purpose is to provide readers with a permanent reference list. In compiling this historial list omissions are inevitable. Assistance from readers by supplying missing references will be appreciated.

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NOTES

ROCHESTER SOCIETY

Last May a group of quality control minded people headed by Mr. Alfred Davis of Bauch and Lomb Optical Company and Mr. Harley Kent of Eastman Rochester Kodak Company approached that Rochester Chamber of Commerce to arrange a dinner to be attended by all persons in the area interested in statistical quality control. This dinner, arranged by Mr. A.E. Crockett and held May 23 by the Industrial Management Council of the Chamber, was attended by 150 men and women. A short business meeting produced an unanimous demand for a permanent organization. Dr. Martin A. Brumbaugh of the University of Buffalo was enthusiastically received as he spoke on the application of statistical methods to industry.

A second meeting was held September 12 at the Rochester Chamber of Commerce with 199 present. The speaker was Dr. Andrew I. Peterson, Director of Manufacturing Research, Radio Corporation of America. He presented the point of view of industrial quality control and told of some personal experiences in applying the techniques. Dr. Peterson speaks with authority and he was at his best at this dinner.

The next meeting of the Rochester Society will be held on October 10. The speaker will be Joseph Manuele, Director of Quality, Westinghouse Manufacturing Company.

QUALITY CONTROL AT SYLVANIA

During the current Spring and Summer months, lecture courses in Quality Control were completed at four Sylvania Plants, located at Ipswich, Massachusetts; Salem, Massachusetts; Towanda, Pennsylvania and Emporium, Pennsylvania. These courses which were given in connection with the Engineering, Science, and Management War Training (ESMWT) program, were set up by Northeastern University in the Massachusetts area and by Pennsylvania State College in the Pennsylvania area. These lecture courses consisting of 12-16 hours each were given by Dr. W.S. Lake of Northeastern University, and by Professor Martin A. Brumbaugh of the University of Buffalo.

The material presented was designed to show the relation of quality control to production problems and to assist in the reduction of spoilage of war materials. Subjects covered included basic theory of frequency distributions the construction and use of control charts, the design of sampling tables, the setting of specification limits, etc.

Approximately seventy-five persons from various production, quality and engineering groups completed the courses, and because of their enthusiasm, it is hoped that arrangements can be made for a continuation of the Statistical Quality Control courses during the coming Fall and Winter months.

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NOTICE

This issue of Industrial Quality Control like the first issue in July is being distributed widely in the Buffalo Area and in other centers to those who have an interest in the development of the control chart approach to industrial problems. The purpose is to give you an opportunity to determine whether the content of the magazine is of sufficient interest to warrant your support. Naturally we hope that the decision will be in the affirmative, and that you will return the attached subscription blank promptly. The November issue will not be sent to you unless some word of your intentions has been received.

Members of the Society of Quality Control Engineers receive the magazine as a privelege of membership. If you are a member of the Society and have paid your dues for the current years, disregard this notice. Those members who have neglected to pay their dues should send in the attached blank immediately.

Industrial Quality Control is made available to qualified members of quality control societies in other centers at a nominal cost of $2.00 per year. The purpose is to acquaint quality control engineers throughout the country with the type of work being carried on in the Buffalo Area and, in general, to promote an exchange of ideas between centers. A large number have sent in their subscriptions during the past two months. They should also disregard this notice.

To all others the subscription price for Industrial Quality Control is $6.00 per year.

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